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ABSTRACT

A Center for the Study of Learning has been proposed by the National Institute of Education. This center is to examine a broad spectrum of higher order cognitive skills including the nature, acquisition, and instruction of these skills. The International Consortium for Learning Research and its coordinating institute, The Ohio State University, share similar goals. Research areas identified by the Consortium include: (1) characteristics of learners (learning style and strategies); (2) characteristics of "learnings" (conceptual systems and processes); and (3) components of instructional systems (methods, materials, techniques, and modes). A major purpose of the Consortium is to synthesize and conduct research relevant to each of the three principal factors of the learning context. An emphasis will be placed on science and mathematics. Another goal is to examine the systematic teaching of generalizable cognitive processes and learning strategies and apply the knowledge to the development of learning models. The report contains a model illustrating the interrelationships of the three program strands. (ML)

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International Symposium for Improvement of Education and International Relations through Cooperative Research

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The Ohio State University
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Goals and directions for science and
mathematics education research in the United States

During the past two years the priority for science and mathematics education has been restablished in the public eye of the citizens of the United States. Books articles, forums and reports have stimulated renewed interest in and a commitment to the quality of education. New ideas have been called forth, new educational strategies suggested, new lines of inquiry opened, and a new sense of purpose articulated. The public is looking to educational leaders and educational researchers to offer suggestions or strategies for school improvement and insights on those problems of theory and practice that must be resolved if we are to strengthen our educational system.

The National Institute for Education in Washington currently supports the work of 4 centers:

Institute for Research on Teaching
Center for the Study of Reading
Educational Technology Center
National Center for Bilingual Research

In addition the need for 11 additional centers has been announced. These include:

Center on Teacher Education
Center on Teacher Quality and Effectiveness
Center on Student Testing, Evaluation, and Standards
Center for the Study of Writing
Center for the Study of Learning
Center on Effective Elementary Schools
Center on Effective Secondary Schools
Center on Education and Employment
Center on Postsecondary Management and Governance
Center on Postsecondary Teaching and Learning
Center on State and Local Policy Development and
Leadership in Education

The combined research agendas of these centers will cover a wide spectrum of educational concerns. Each Center will ask different kinds of questions and will operate in a different arena of inquiry, all will share a single purpose: to strengthen America's classrooms.

The Center which most nearly reflects the goals of the International Consortium for Learning Research is the NIE Center for the Study of Learning.

The NIE Center for the Study of Learning will examine a broad spectrum of higher order cognitive skills, including how students acquire new knowledge, integrate it with what they already know, reflect critically on it, and reason and solve problems with it. The following broad questions will guide the Center's work: (1) what is the nature of these skills? (2) how are they acquired? and (3) how can they be taught?

The topics suitable for investigation at the NIE Center for the Study of Learning are organized around four foci: (1) the nature of cognitive skills; (2) the acquisition and development of cognitive skills; (3) individual preferences and differences in cognitive skills; and (4) instructional influences on cognitive skills.

As the coordinating institution it is the intent of The Ohio State University members of The International Consortium for Learning Research to coordinate and facilitate the communication and collaboration of scholars, developers, and practitioners. To accomplish such a mission it will be necessary to identify leaders around the world in places where interest in excellence of learning exists. These sources will be tied together through a communication network and a collaborative effort system so that skills and expertise can be pooled toward a better understanding of learners, "learnings," the development of more valid instructional systems, and a more effective implementation of theory into practice.

The Consortium will focus on three principal factors of the learning context (See Figure 1):

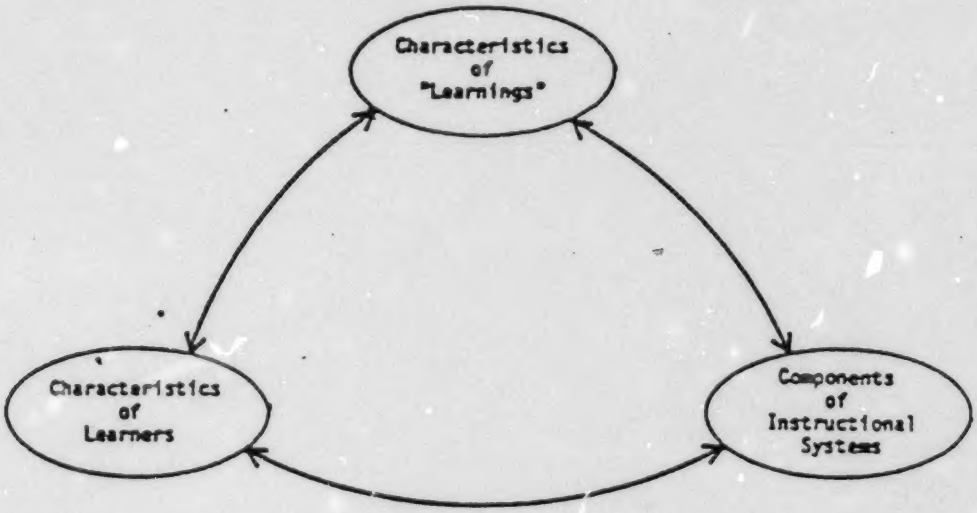

Figure 1. Principal Factors of Learning Context

The delineation of each of these factors and the identification of the critical features of each would constitute a first level effort. This endeavor would then lead to the study of relationships among these factors across content domains in order to develop models of learning and prototypes for curricula and instructional activities.

The consortium coordinators at Ohio State University view learning as an outcome of the interactions of these three principal factors:

a. Characteristics of learners include basic cognitive processes and learning strategies common to all learners. Learning style is the characteristic behavior pattern of cognitive processes and learning strategies which differentiates individuals.

b. "Learnings" have been traditionally defined as those concepts, skills, and processes specific to a subject matter area within a content domain. A current view is that of conceptual systems and processes (E.G., problem-solving) which provides organization and unity across content domains. Learner awareness of the basic cognitive processes and learning strategies (a metacognitive approach) is another dimension of the factor of "learnings."

c. Components of instructional systems include the interactions among teaching methods, teaching materials, teaching techniques, delivery systems, presentation modes, motivation techniques, environmental features, and environmental organization.

A major purpose of the Consortium is to synthesize and conduct research relevant to each of the three principal factors of the learning context. Research directed toward the interrelationships of the three factors is of special significance. The Consortium will conduct research to understand generalizable cognitive processes and learning strategies. The Consortium will also investigate characteristic learning behavior patterns of individuals (learning style). Both strands of research will be related to instructional systems that promote higher order thinking skills, problem solving competence, and efficient learning in science and mathematics. Special attention will be given to the impact of new technologies on the three factors of the learning context.

The second purpose of the Consortium is to synthesize and conduct research directed toward the systematic teaching of generalizable cognitive processes and learning strategies to increase higher order thinking skills and/or develop adaptive, coping behaviors. Where teaching cognitive processes and learning strategies is inappropriate, ways to modify the instructional systems to match the individual's learning style will be explored. This research is based upon two assumptions about learning: (2) learning is a behavior that spans human development, and (2) learning is affected by and should be responsive to the needs of different learners (e.g., "normal," culturally diverse, exceptional, disadvantaged).

The third purpose of the Consortium is to use the knowledge of learning in the development of learning models. These learning models will reconsider, modify, and expand existing learning theories. The models should be responsive to the

knowledge gained about all learners, and should be applicable to the content domains of science and mathematics, building competence in problem solving. These learning models should be consonant with the projected needs and resources of tomorrow for the member countries.

An examination of current research and theory can be organized around the three principal factors of the learning context and their interrelationships (See Figure 1). The validity of this schema will be further explored by the Consortium.

a. Characteristics of Learners

Basic cognitive processes and learning strategies have been used to describe the nature of the learner. A variety of cognitive, affective-motivational, and psychological-environmental variables have been identified as relevant to these processes and strategies (Keefe, 1985, in press).

1. Perceptual Modality Strengths/Preferences
2. Simultaneous/Successive
3. Attention
4. Field Independence/Dependence
5. Focusing/Scanning
6. Inductive/Deductive
7. Reflective/Impulsive
8. Complex/Simple
9. Narrow/Broad
10. Sharpening/Leveling
11. Active/Reflective
12. Thinking Judgment/Feeling Judgment
13. Social Motivation
14. Achievement Motivation
15. Anxiety
16. Need for Structure
17. Risk Taking/Cautiousness
18. Persistence
19. Time of Day Preferences
20. Environmental Elements
21. Need for Mobility

There is a substantial body of research directed toward the understanding of each of these variables and their relationship to culturally diverse, exceptional, and disadvantaged learners (See a review by Kirby, 1979). These variables have also been linked to age and gender differences (e.g., Berlin & Languis, 1980). Additional research in this area is warranted as current findings are neither consistent nor conclusive.

Another promising area of inquiry is the exploration of patterns of behavior resulting from the interrelated cluster of these variables relevant to the basic cognitive processes and learning strategies (i.e., learning style).

> Learning style is that consistent pattern of behavior and performance by which an individual approaches educational experiences. It is the composite of characteristic cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment. It is formed in the deep structure of neural organization and personality which molds and is molded by human development and the cultural experiences of home, school, and society (Languis, 1983).

Research on the learner needs to attend to both the identification and exploration of basic cognitive processes and learning strategies as well as their unique contribution to the individual's learning style. Processes and strategies that promote higher order thinking skills and efficacy of learning for all learners as well as specific groups of learners should be delineated.

b. Characteristics of "Learnings"

The nature of society and education has been greatly influenced by technological/communication advancements and demographic changes. The increased volume of knowledge, the advent of new fields of knowledge, and the crossing of standard and nonstandard disciplines of study require a revised definition of "learnings." One such definition could include content related to basic cognitive processes and learning strategies (a metacognitive approach) and the application of these processes and skills in problem solving (applied information processing). Simply put, "learnings" could include learning about thinking and learning to think.

Research and theory relevant to basic cognitive processes and learning strategies (learning about thinking) have dealt with specific ways in which learners can generate meaning for themselves and develop associations between what is learned and their own memory storage system to facilitate learning and retrieval. Wittrock (1978) has described this process as a "generative" way of learning. Organizational techniques based upon subsuming concepts and sequencing have been suggested by both Ausubel (1968) and Gagne, et. al. (1962). Ausubel labels his strategy "advance organizers" while Gagne uses the term "hierarchial structure." The use of imagery, such as mental pictorial representations (Bower, 1970; Luria, 1968), concrete words (Anderson, 1974), and the drawing of objects (Levin, 1976) has been related to successful learning. Verbal encoding (Bower & Clark, 1969) and analogies (Gentner, 1980; Sternberg, 1977) have also been related to learning and recall. The use of mnomenics such as rhymes, acronyms, acrostics, pegwords, the loci method (Ross & Lawrence, 1968), and the keyword method (Levin, 1981) have also been shown to be effective.

The second aspect of the current definition of "learnings" involves learning to think or applying cognitive processes and learning strategies to problem solving. Gagne suggests that problem solving is the ultimate goal of education.

Problem solving is germane and specific to all content area domains. Since the 1960's, the science curriculum has identified problem solving skills.

The nature of problem solving is a critical area for inquiry by the Consortium. Relatively little attention has been given to either factors involved in the development of problem solving skills or efficiently teaching them to children. In science, Huntsberger (1976) evaluated the use of materials in the development of divergent-productive thinking associated with problem solving. Lester (1980) has investigated some environmental, personal, affective, and cognitive factors which affect problem solving success in mathematics. In social sciences, Russell and Roberts (1979) suggest that requisite problem solving skills can be taught. The research of Heath and White (1983) and Heath, White, Berlin, and Parks (1985) has specifically examined the generation of alternatives (a requisite skill) and presentation mode (interview vs. computer). Many instructional "problem solving" programs aimed at various age levels, specific content domains, or across content domains have been developed and disseminated (See the literature review on instructional systems). As such, research directed toward the examination of the features of problem solving behavior and how to effectively teach problem solving skills to all learners is needed.

c. Components of instructional systems

The third factor of the learning context, instructional systems, refers to the interaction among teaching methods, teaching materials, delivery systems, presentation modes, motivation techniques, environmental features, and environmental organization. Other terms that are related are pedagogy, instructional tools, teaching strategies, and the instructional experience. Figure 2 illustrates some features that may be used to describe components of the instructional system.

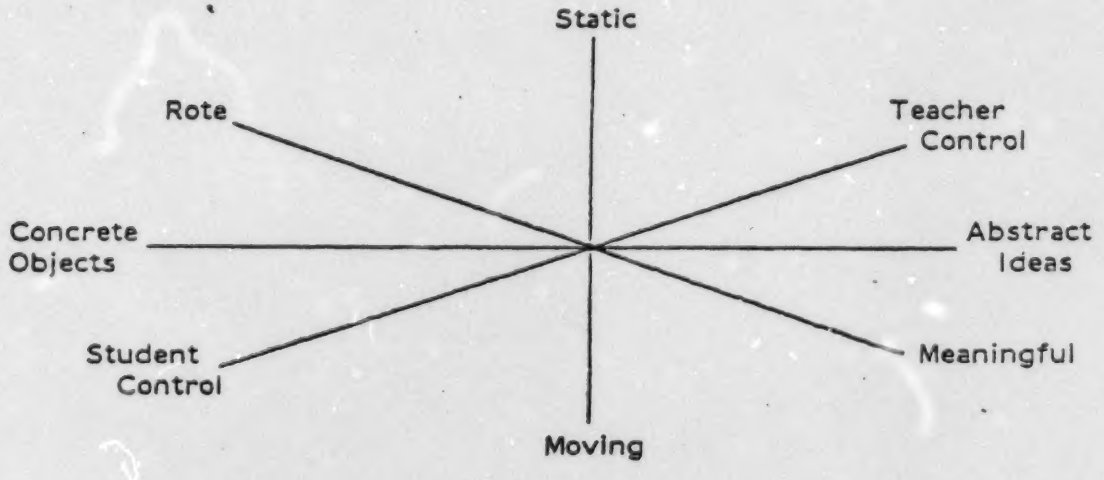

Figure 2. Descriptive Features of Instructional Systems Components

Some of the current learning theories and their influence on components of the instructional system also need to be examined by the Consortium. For example, educators have accepted a general teaching strategy based upon a concrete-semiconcrete-abstract continuum. It has been suggested that learning should begin by concrete experiences with manipulative materials, then extend understanding through abstract thinking (i.e., symbols, letters, numbers). Several eminent theorists support this model (e.g., Bruner, Dienes, Piaget). It should be noted however, that this instructional continuum may not be appropriate to all learners nor the development of specific concepts, processes, and skills within the subject matter areas (Berlin & White, 1985).

The impact of the new technology upon the instructional system is a critical area for inquiry. There is much to be learned about the calculator and computer and the development of problem solving and communication skills, the relative effectiveness of branching and simulation strategies, the development of spatial ability through computer graphics, and the use of structured languages. The use of the computer with special learners also warrants investigation. For example, Waldron and Rose (in press) found that deaf students using computer graphics performed as well as normals even though their achievement in the regular school curriculum was substantially below their classmates.

d. Interrelationship of Learning Context Factors

There exists a complex universe of variables that affect learning. Much educational research has suffered from fragmentation and a lack of direction. The research has also been noncumulative, often inconclusive, and even contradictory. The description of a substantial, robust theory base, (i.e., models of learning) is needed to direct educational research.

One of the major activities of the Consortium is to develop and test models of learning which reflect the knowledge base. The members suggest that this knowledge base involves research about the learners, "learnings", and instructional systems. Models of learning need to focus on the interrelationship of these three factors. Figure 3 graphically summarizes our current understanding of this interrelationship. The Consortium's mission is to validate this model, better understand each of the factors and their interrelationship, and to facilitate vertical movement of learners to promote learning.

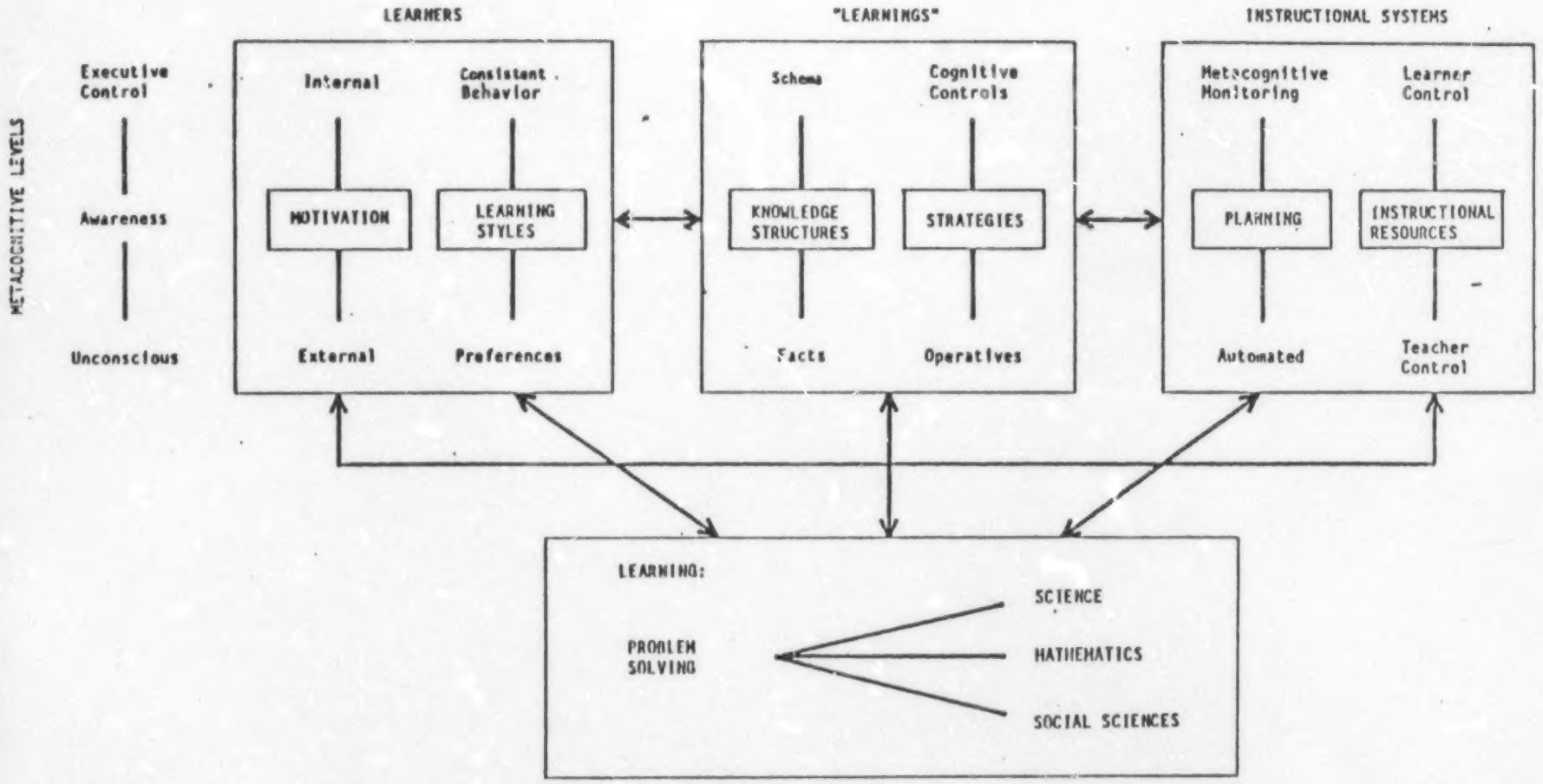

Figure 3. Interrelationship of Learning Context Factors

Note: Each vertical strand is not the exclusive domain of any one factor.

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